AC LINE VOLTAGE REGULATOR
KS-15508
MOTOR-DRIVEN AUTOTRANSFORMER TYPE
OPERATING METHODS

1. GENERAL

1.01 This section covers the operation of ac line voltage regulators, KS-15508, of the motor-driven, continuously tapped autotransformer type. They were designed to provide regulated ac power from an ac power service which is subject to variations in voltage greater than the limits acceptable for the connected apparatus. They are suitable for use over a range of 55 to 65 cycles and are available, in a variety of capacities, for the following voltage ratings.

Range Input Volts	Regulated Output Volts	Phase
95 to 135	115	1
195 to 255	230	1
180 to 225	208	1
195 to 255	230	3
180 to 225	208	3

Caution: As these regulators include circuits of 115 volts or more, care must be used to avoid contact with exposed terminals. Whenever practicable, maintenance work should be done with the equipment disconnected from the power supply.

1.02 This section is reissued to add the list 10 line voltage regulator.

1.03 The apparatus is intended for general application, as required.

1.04 Routine checks should be made during a period when they will cause the least unfavorable reaction on service.

1.05 For the maintenance of the motor-driven autotransformer, see Section 028-706-701.

1.06 Information in this section is arranged under the following headings:

2. OPERATION

Description

2.01 The 208/230 volt, single-phase regulator (see Fig. 1) consists of a motor-driven variable autotransformer, T3, a fixed-ratio buck-boost transformer, T4, an output voltmeter, and associated control equipment. A tapped autotransformer, T5, is provided to supply 115 volts through a fuse to the control circuit. Terminal 4 of this autotransformer is used in 230-volt service and terminal 3 in 208-volt service. Terminal M of the variable autotransformer T3 (X wiring) is connected through a fuse to supply the motor.

2.02 The 115-volt, single-phase regulator is similar, except that the control circuit and motor are connected (W wiring) through fuses to the lines and that transformer, T5, is omitted as well as terminal M of T3.

2.03 Single-phase regulators are protected against excessive current, either by a fuse connected in the brush lead (Y wiring) or by a manually operated circuit breaker (Z wiring) which has its operating coil similarly connected.

2.04 The 208/230 volt, 3-phase regulators (see Fig. 2) consist of three variable autotransformers, T3, assembled so as to be driven by a single motor, three fixed-ratio buck-boost transformers, T4, an output voltmeter, and associated control equipment. Two tapped autotransformers, T5, are provided to supply 115 volts, through fuses, to the motor and the control circuit. Terminal 4 of these autotransformers is used in 230-volt service and terminal 3 in 208-volt service. All 3-phase regulators regulate only one phase, so load unbalance might result in poorer regulation for the unregulated phases than that specified.

2.05 The list 10, 208/230-volt, 3-phase regulator (see Fig. 3) consists of four variable autotransformers, T1, assembled so as to be driven from a single motor, two fixed-ratio buck-boost transformers, T3, two paralleling choke coils, T2, an output voltmeter, and associated control equipment. Two tapped autotransformers, T4, are provided to supply 115 volts, through fuses, to the motor and the control circuit. Terminal 4 of these autotransformers is used in 230-volt service and terminal 3 in 208-volt service.

2.06 In all cases, the output voltage is adjusted by means of the OUTPUT VOLTAGE potentiometer (see Fig. 1). The sensitivity of the regulator, defined as the value of voltage departure from the nominal which will cause the regulator to correct, is adjusted by means of the SENSITIVITY rheostat. These controls are mounted on the panel and are ajdusted by means of a screwdriver. The pilot lamp, mounted on the control panel, indicates the presence or absence of power in the control circuit. The remainder of the control circuit is located in the removable control unit. The entire control circuit is shown schematically in Fig. 4.

2.07 The output voltage of the variable autotransformer is applied through its associated fixed-ratio transformer to boost or buck, as required, the voltage at the output side of the regulator. Variation in the output voltage of the autotransformer is obtained through the rotation of its brush by the motor under the control of relays which are located in the control unit.

2.08 In the control circuit (see Fig. 4), the output voltage of the regulator is applied, either directly or through an autotransformer, across winding 1-2 of transformer T1, through resistors R13 and R14, the coils of relays RL1 and RL2, and across the thyratron tubes V1 and V2. Windings 3-4 and 4-5 of T1 are part of a bridge circuit including resistors R6 and R7, the voltage-sensitive unit BU1, and potentiometer R10 (mounted on the control panel). The primary winding of T2 is connected as the measuring element across the bridge. Windings 3-4-6 of T1 supply the heaters of V1 and V2 and a bias rectifier consisting of two varistors 1N34, resistor R5, and capacitor C1. This rectifier provides the negative dc bias for the grids of thyratron tubes V1 and V2. Rheostat R11 (mounted on the control panel) is connected, through part of R10 and the primary of T2, to shunt capacitor C1 and serves as a means of adjusting the grid bias which controls the sensitivity of the regulator. The secondary winding of T2 is connected to the grids of V1 and V2.

Regulation

2.09 In operation, at the voltage for which the regulator is adjusted, the voltage between terminal 5 of the voltage sensitive element (BU1) and the movable contact of R10 is equal to the voltage between the movable contact of R10 and terminal 7 of BU1. Since the voltage between T1 terminals 3-4 equals that between T1 terminals 4-5, there is no difference of potential across the primary of T2 and only the dc bias voltage will appear on the grids of V1 and V2. If the output voltage increases, there will be a corresponding increase in the voltage across the secondary of T1, equally divided between terminals 3-4 and 4-5. Due to the characteristics of BU1, the voltage between terminal 5 of BU1 and R10 contact will be greater than between R10 contact and terminal 7 of BU1. Current will flow in T2 and, consequently, ac voltage will appear at the grids of V1 and V2. If the magnitude of this voltage is sufficient, the appropriate tube will conduct, causing its associated relay, RL1 or RL2, to operate and the motor to rotate the brush of the autotransformer. As a result, the decreasing output voltage will bring the bridge to a balanced condition and the motor will stop.

2.10 A decrease in output voltage will unbalance the bridge in the opposite direction and the other tube will conduct, producing the required correction.

2.11 When R11 is adjusted to decrease its resistance, resulting in a decreased grid bias, a smaller departure of the output voltage from its regulated value will call for a correction. If this resistance is decreased excessively, the regulator will hunt. In practice, this rheostat should be adjusted so that the motor operates frequently enough to keep the output voltage within the required limits but not so frequently as to cause unnecessary wear.

Initial Preparation and Adjustments

2.12 When putting the regulator into service initially, see that:

(a) All equipment supplied by the regulator is disconnected from it.

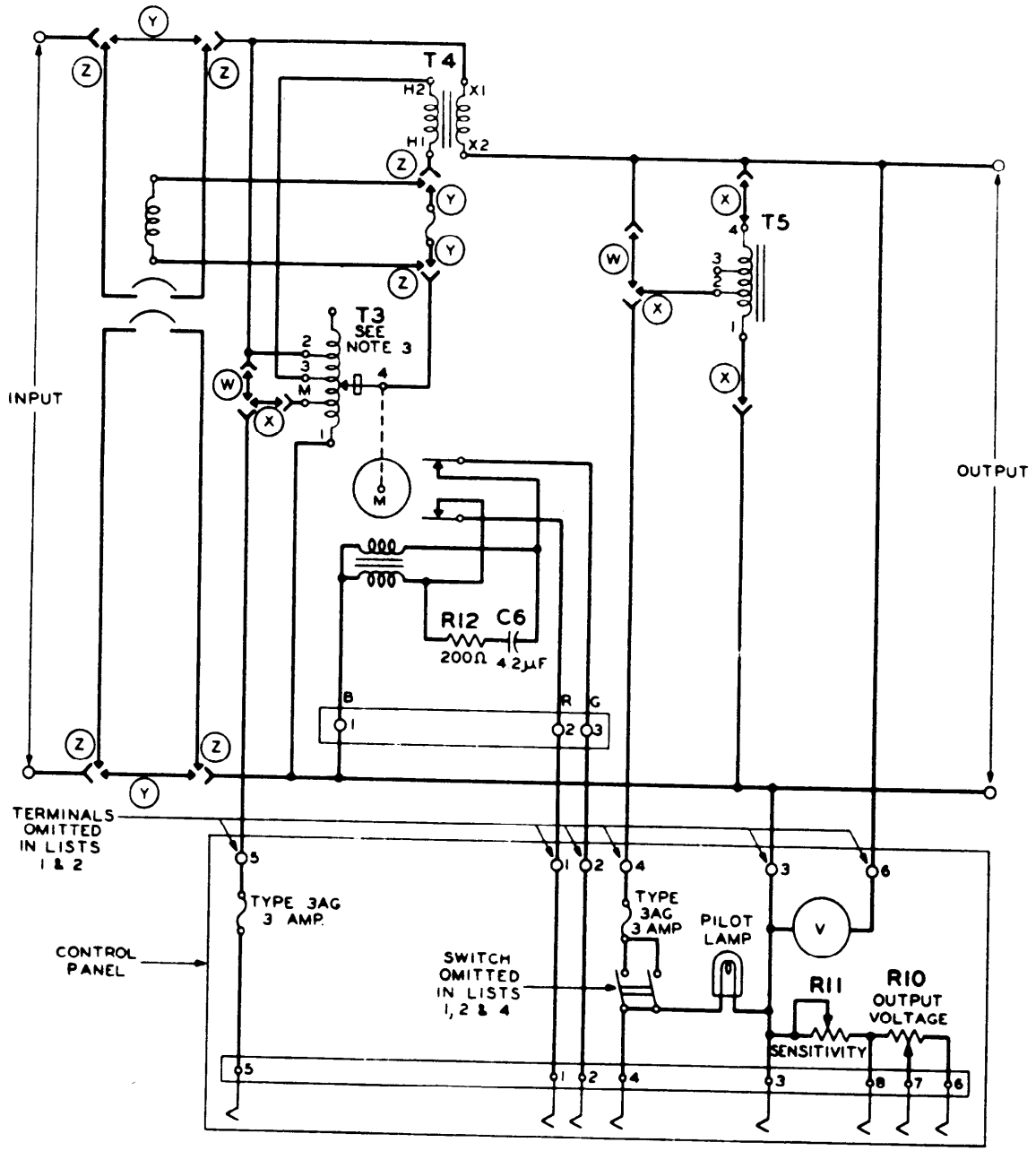
(b) Fuses of the correct sizes are in place, as required.

(c) Transformer T5 is connected at the correct tap for the power service voltage.

(d) The circuit breaker or the control circuit switch, as provided, is closed. This will light the pilot light and apply power to the control circuit. After an interval of 15 to 20 seconds, the regulator will operate, if correction is required. Remove the dress cap over the SENSITIVITY control and with a screwdriver adjust this control until the regulator hunts. Then back it off a small amount to stop the hunting. Replace the dress cap over the control.

(e) The OUTPUT VOLTAGE control, as covered above, shall be adjusted to bring the output voltage within the limits specified for the office, observing the voltmeter mounted on the panel.

(f) The output voltage is readjusted when the load is applied, if required.



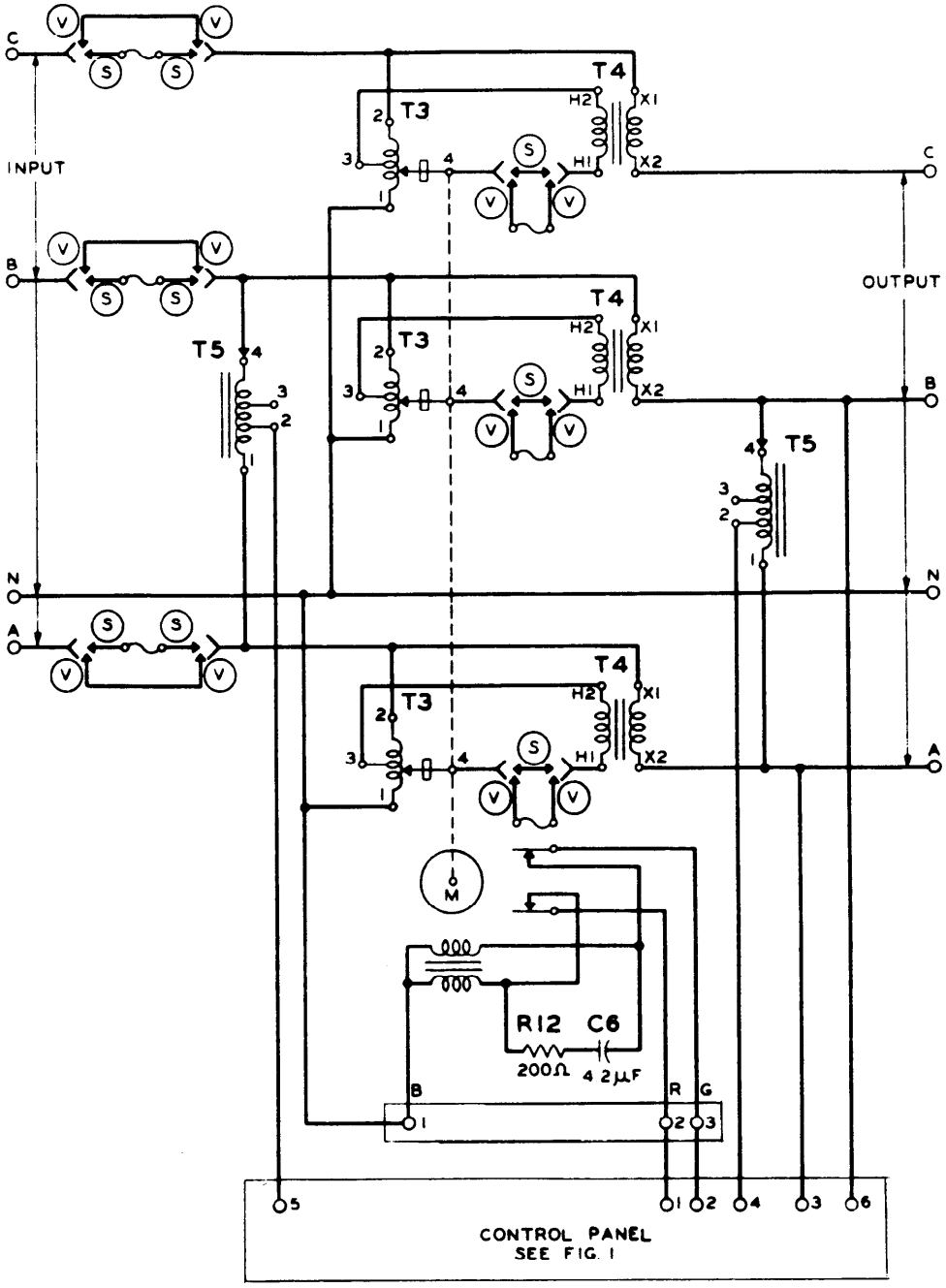
NOTES:

1. OPTIONAL EQUIPMENT FURNISHED AS FOLLOWS:

LIST	OPTION
1 & 2	W & Z
3	W & Y (40 AMP)
4	X & Z
5	X & Y (30 AMP)

2. IN TRANSFORMER (T5), CONNECT TERMINAL 4 FOR 230 VOLTS, TERMINAL 3 FOR 208 VOLTS
3. IN LIST 4, TERMINAL 2 OF (T3) IS LOCATED AT THE EXTREMITY OF THE WINDING

Fig. 1 - Circuit of Control Panel and Single-phase Regulators



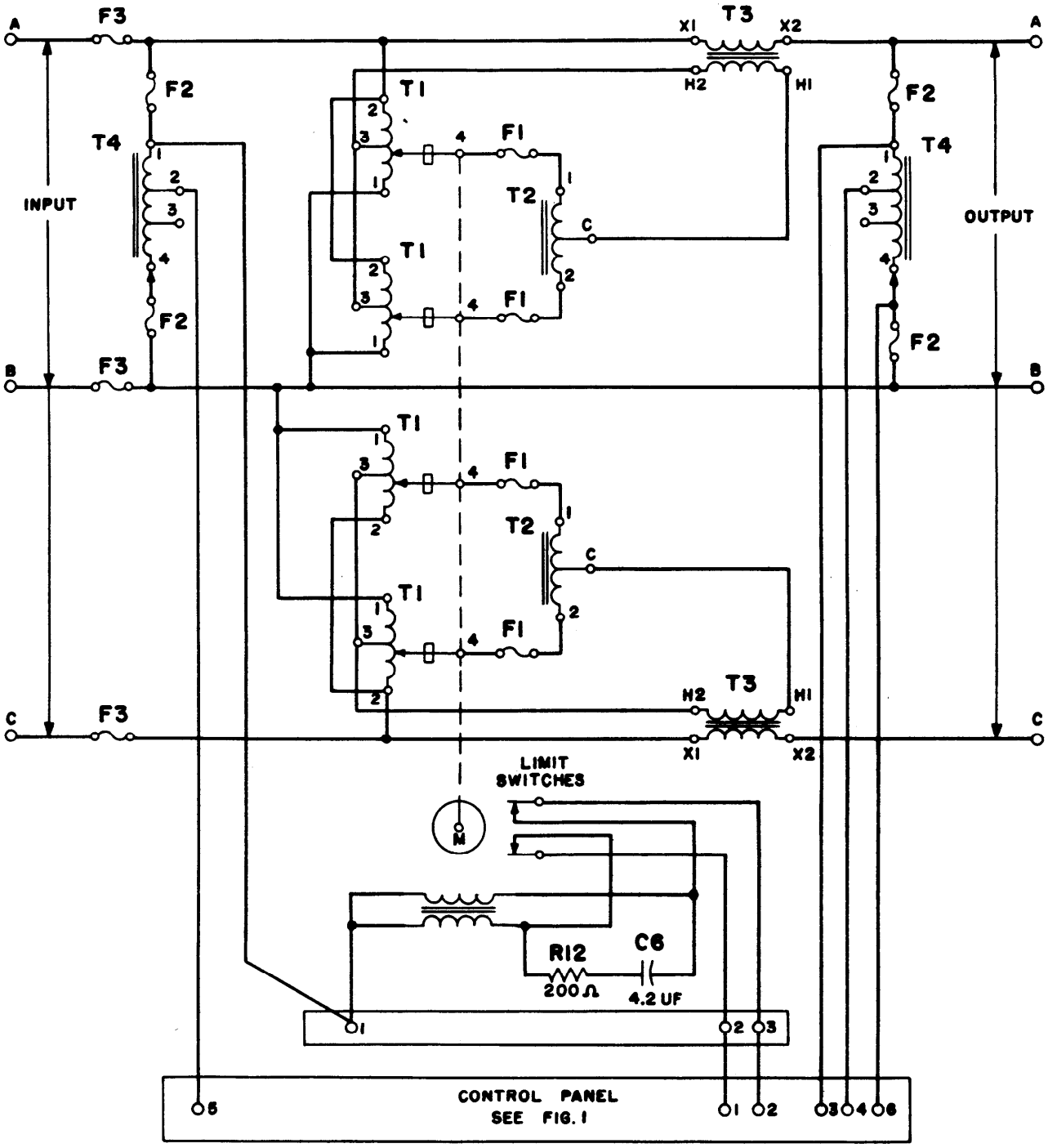
NOTES:

1 OPTIONAL EQUIPMENT FURNISHED AS FOLLOWS:

LIST	OPTION
6	S (25 AMP)
7	S (40 AMP)
8	V (35 AMP)
9	V (40 AMP)

2 IN TRANSFORMER (T5), CONNECT TERMINAL 4 FOR 230 VOLTS, TERMINAL 3 FOR 208 VOLTS.

Fig. 2 - Circuit of Three Autotransformers, 3-Phase Regulators

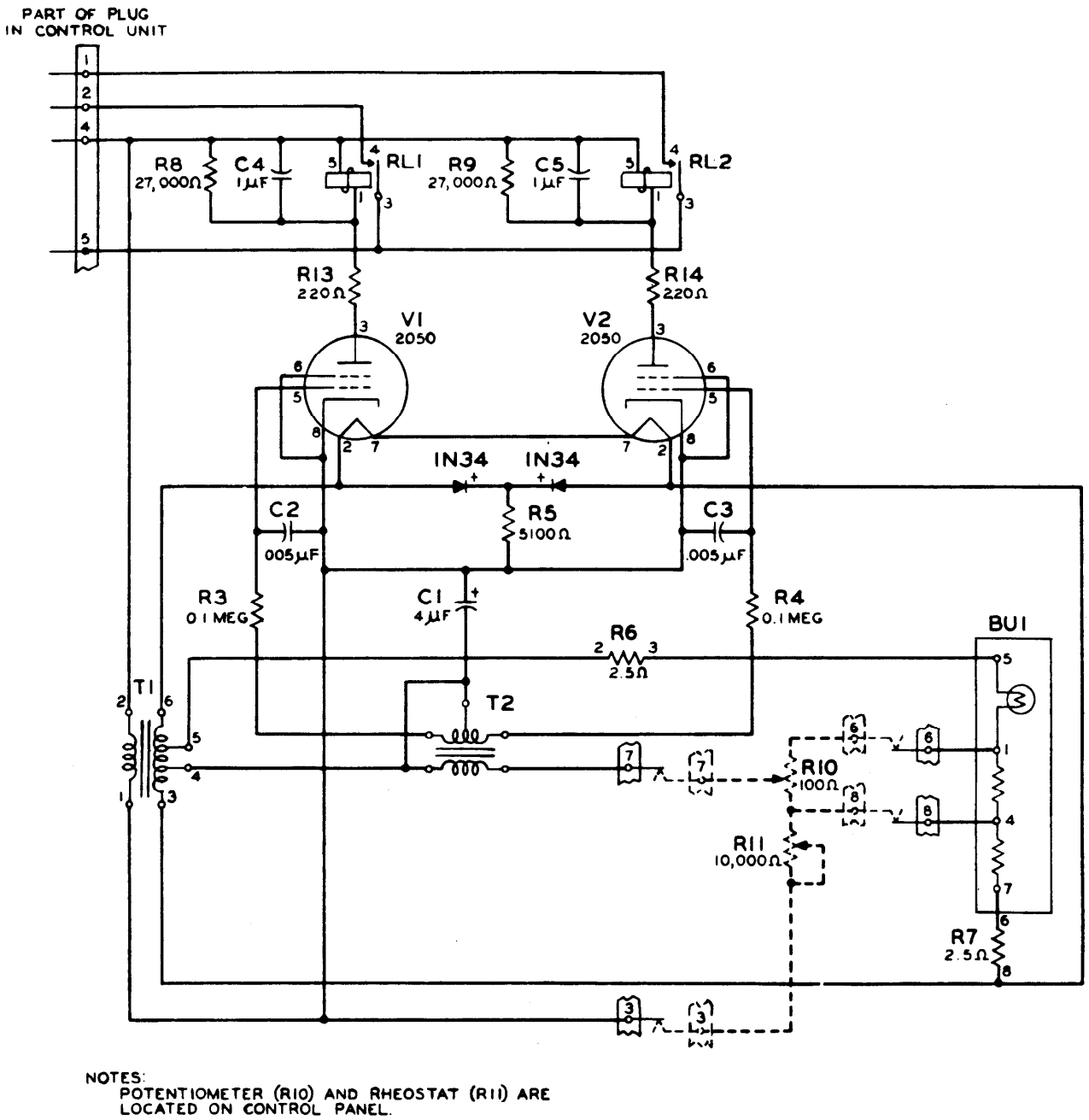


NOTES:

1. FUSES: F1- 30 AMPERES
   F2- 3 AMPERES
   F3-175 AMPERES

2. IN TRANSFORMER (T4) CONNECT TERMINAL 4 FOR 230 VOLTS, TERMINAL 3 FOR 208 VOLTS.

Fig. 3 - KS-15508, List 10, Regulator Circuit



NOTES:
POTENTIOMETER (R10) AND RHEOSTAT (R11) ARE LOCATED ON CONTROL PANEL.

Fig. 4 - Control Circuit - Schematic

Routine Adjustments (Normal Operation)

2.13 In normal operation the action of the regulator should be checked to be sure that corrections are made only as required to keep the output voltage within limits. Correct by adjustment of the SENSITIVITY control.

2.14 The BU1 element is subject to aging, with the result that the output voltage of the regulator will decrease at the rate of approximately one volt per month. Observe the voltmeter and adjust the OUTPUT VOLTAGE control as required. The element should be replaced when the OUTPUT VOLTAGE control has been adjusted to the end of its travel.

2.15 In general, a life of 2 years may be expected of the thyratron tubes and the BU1 voltage sensitive element. These are mounted in the control unit by plugging into sockets and, when defective, should be replaced with new ones.

2.16 The relays, which also are mounted in sockets in the control unit, are expected to have a life in excess of 5 years and when defective should be replaced with new ones.

2.17 The SENSITIVITY and OUTPUT VOLTAGE controls should be replaced when defective.

2.18 The control unit is connected through a jack and plug arrangement and is removable. It is held in place by two screws which are located at the top and bottom, near the center of the control unit. If trouble is definitely traced to this unit, after checking the replaceable elements (see 2.14 through 2.17) and the motor (see 2.19), it is recommended that this unit be replaced with a new one.

2.19 To check the motor, remove the control unit, locate the motor terminal board, and, with the regulator disconnected from the power source, remove the three motor connections. Apply 115 volts, 60 cycles, from an external source, to the black and green leads and then to black and red leads. It should be possible to run the brush of the variable autotransformer from end to end of its travel. If this is not possible, check the several components of the motor circuit, including the motor itself, and make replacements as indicated.

3. GENERAL TROUBLES

3.01 If any of the following troubles are encountered, it is suggested that the possible causes be checked in the order listed.

Trouble	Possible Cause
No output voltage	AC supply fuse or brush circuit fuse blown
	Circuit breaker open
High or low output voltage	AC line voltage outside limits
	Control circuit switch in OFF position
	OUTPUT VOLTAGE control out of adjustment
	Motor supply fuse blown
	Control circuit supply fuse blown
	Failure of thyratron tube or relay in control circuit
	Failure of motor
	Failure of autotransformer
Output voltage unstable	SENSITIVITY control out of adjustment
	Failure of bias supply to grids of thyratron tubes
3-phase output voltage unbalanced	One supply fuse blown
	Brush on autotransformer open